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Seventy-two grade 8 students were randomly assigned to one of four experimental groups. One group studied five programed lessons in structural grammar, written without use of symbols or diagrams. A second group studied the same content presented with a symbolic notation to represent the grammar concepts. A third group studied the same content except that the symbolic notation of the second group was used in figural sentence-tree diagrams. The fourth group, a control group, studied five programed lessons in how to read poetry. The students studied the lessons in their regular English classrooms over a period of 1 week. Post-tests were given 2 days and 2 weeks after the last lesson. Test results showed that all three experimental groups learned and retained more knowledge of grammar than the control group. The lessons using symbolic notation and diagrams were each superior to the verbal presentation. Low ability students did not benefit from the diagrams and only high ability students mastered the strictly verbal presentation. The symbolic notation produced significant learning at all ability levels. The experiment seemed to show that the teaching of verbal concepts is facilitated by appropriate symbols and diagrams, provided students understand these nonverbal materials. (Author/LH)

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Technical Report No. 64

A COMPARISON OF VERBAL STATEMENT, SYMBOLIC NOTATION AND FIGURAL REPRESENTATION OF GRAMMAR CONCEPTS

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Report from the English Language and Composition Project
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PREFACE

The overall purpose of the R & D Center's Program 2—Processes and Programs of Instruction—is to improve educational practice through the application of knowledge about cognition to instructional problems in disciplines such as English language and composition.

The study reported in this document was designed to gain information about the importance of three modes of representation in presenting a series of grammar concepts. One mode was entirely verbal. The second was based on a symbolic notation and the third was based on diagrams. Each mode —verbal, symbolic, and figural—was tested with subjects of high, medium, and low ability to see the relationship to the type of mode and intelligence.

The study illustrates process-related research and contributes to the understanding of cognitive learning within instructional systems.

T. A. Romberg
Director of Program 2

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ABSTRACT

Seventy-two eighth graders were randomly assigned to one of four experimental groups. One group studied five programed lessons in structural grammar that were written without use of symbols or diagrams. A second group studied exactly the same content, but their version used a symbolic notation to represent the grammar concepts. A third group studied the same content except that the symbolic notation of the second group was used in figural sentence-tree diagrams. The fourth group was a control group that studied five programed lessons in how to read poetry.

The Ss studied the lessons in their regular English classrooms over a period of one week, and did not know an experiment was in progress. A posttest was given two days after the last lesson, and an alternate form of the posttest was given two weeks later as a measure of long-term retention. The test results were analyzed by analysis of variance and showed that all three treatment groups learned and retained more knowledge of grammar than the control group. The versions using symbolic notation and diagrams were each superior to the verbal presentation. The mode of presentation interacted with the intelligence of Ss. Low ability Ss did not benefit from the diagrams, and only high ability Ss mastered the strictly verbal presentation. The symbolic notation produced significant learning at all ability levels. The experiment seemed to show that the teaching of verbal concepts is facilitated by appropriate symbols and diagrams, provided Ss understand these nonverbal materials.

I
INTRODUCTION

STATEMENT OF THE PROBLEM

A subject-matter area such as English grammar may be taught entirely verbally. Yet, it may be that by the use of nonverbal modes the teaching of a group of such concepts will be facilitated. The present experiment tested three modes of representation in presenting a series of grammar concepts: one mode was entirely verbal; a second was based upon a symbolic notation; and a third used diagrams. Each mode—verbal, symbolic, and figural—was tested with Ss of high, medium, and low ability to see whether the appropriateness of the mode varied with intelligence.

RELATED RESEARCH

Bruner (1966), in developing a theory of instruction, considered the relationship between the ability of the learner to master a subject and the mode of representation of that subject. In his words, "Any idea or problem or body of knowledge can be presented in a form simple enough so that any particular learner can understand it in a recognizable form [p. 44]." The modes of representation could be either enactive, iconic, or symbolic, and the actions, pictures, and symbols implied by these respective modes would vary in difficulty and utility for people of different ages, backgrounds, and styles. A mode would be appropriate or inappropriate according to the subject matter presented. Bruner further stated that a particular mode may alter the economy and power of knowledge; that is, some modes will induce comprehension with less memory strain than other modes, and some modes will facilitate the connection of seemingly unrelated information while other modes will be literal "dead-ends."

The factor analytic work on the structure of intellect has pointed to the existence of separate identifiable abilities which are specific to the content involved (Guilford, 1968). The contents, whether figural, semantic, or symbolic, each require a unique form of reasoning. A person may, therefore, be very adept when making symbolic transformations, but he may be inept if a change in content requires him to make figural or semantic transformations. There is the implication that the content, which is no more than the class of information being presented, may one day be appropriately varied for each individual depending on his strong and weak abilities. Already studies have shown that the symbolic factors in the structure of intellect predict success in algebra (Guilford, Hoepfner, & Petersen, 1965) and that spatial reasoning factors are more valid in predicting proficiency in a modern algebra course than in a traditional course (Osburn & Melton, 1963).

For the present study, what is of value from the thinking of Bruner and Guilford are the suggestions that several specific kinds of reasoning exist. It may be pedagogically sound and instructionally advantageous to involve several of these abilities when teaching. In all probability this is what good teachers do anyway, but the verification of this idea under controlled conditions is important. Grammar, as a subject-matter area, is almost entirely in the content area that Guilford calls semantic. The question of whether the teaching of grammar should also be entirely semantic and verbal or whether one should draw upon other contents and abilities, such as the spatial and figural and the use of symbol systems, is more than merely academic. It has important implications for educational processes in general.

Experimental studies have shown that involving figural content in a predominantly verbal task can speed learning. Paired-associates may be learned more easily by the use of pictorial representations of the stimulus and response pairs than by the use of only the stimulus and response words (Rohwer, Lynch, Levin, & Suzuki, 1967; Paivio & Yarmey, 1966). The same appears to be true for the learning of

serial lists (Herman, Broussard, & Todd, 1951) and in recognition tasks (Jenkins, Neale, & Deno, 1967). Runquist and Hutt (1961), however, showed that in learning verbal concepts (round, soft, sharp) pictorial representation of instances was poorer than the verbal presentation of instances (i.e., ball, bed, knife). This result is explained to some extent by later studies (c.f., Bourisseau, Davis, & Yamamoto, 1967) which have shown that the abstract nature possessed by words leads to more sense-impression responses than the corresponding illustrative materials. Reynolds (1966), using a task that had the general characteristics of meaningful learning in that both simple verbal learning and complex conceptual learning were required, showed that the integration of verbal and perceptual stimuli into a total structure produced the best conditions for learning and transfer. The cognitive organization resulting from the verbal and perceptual combination facilitated both simple and complex learning. The organizational aspect of perceptual stimuli was seen as a powerful factor in basic learning processes.

The findings of Runquist and Hutt suggest that figural material may at times lead to responses different from those elicited by words. The difference may lie in the specificity of the response. Vernon (1953) had earlier contended that the content of written text is by no means always clarified if the text is accompanied by figural materials such as graphs or charts. Vernon pointed out that only the specific facts shown in the chart or graph are better remembered than the corresponding verbal statements and that this emphasis on specific points was liable to interfere with the understanding of general arguments. When she tested the use of pictures and charts in articles about disease, Vernon found that the points emphasized by pictures were remembered, but possibly at the expense of other information, and that charts were not uniformly successful in presenting materials covered verbally. The impression was that figural material was neither favorable nor unfavorable to the presentation of general information, though in some cases it would stress a specific point successfully.

Dwyer (1967) compared an oral presentation to other treatments in which the oral soundtrack was accompanied by either abstract line drawings, detailed shaded drawings, or photographs. The content consisted of the parts of the heart and their functions. Ss were tested on terminology, comprehension, identifying parts on a three-dimensional model, and drawing parts of the heart in the proper positions. Abstract line drawings and detailed shaded drawings each produced better overall learning and more accurate drawing of parts than did the oral presentation. These two types of illustrations produced slightly, but not significantly, more learning on the other measures also. Photographs did not produce learning beyond that achieved by an oral presentation alone. Dwyer concluded that types of presentations were differentially effective depending on the specific educational objectives. An oral presentation alone may be appropriate for teaching terminology, but for relationships among parts, a simplified line drawing may be needed.

A study by Scandura (1967) adds another dimension to the question of whether to involve several abilities in the learning of materials. He showed that mathematical rules in symbolic form were easier to learn than the equivalent verbal statements, but once learned the symbolic and verbal statements could be applied to problems equally well. Scandura also noted that the symbolic notation was successfully used only if the symbols were made initially meaningful. Thus, a decision to use a symbol system, or illustrative material, in addition to verbal statements may have to be based on whether one must first do extensive teaching for the symbols and illustrations to be meaningful.

If meaningful, the symbols and figural materials must still pass the test of economy and power prescribed above by Bruner. They must be economical by providing comprehension with minimum memory strain, and they must have power by enabling the learner to connect new information and related concepts to the existing framework.

The use of spatially organized materials is consistent with a cybernetic view of the learner. In this view the individual is a feedback system which actively detects and controls environmental stimuli. An important ingredient in this feedback system is the perception of spatial organization. In applying this view to the design of instructional materials, Smith and Smith (1966) concluded that nonverbal illustrative content integrated with verbal content will structure the pattern of learning by revealing organizational features of the subject matter and providing visual patterns as background for verbal materials. Following a survey of the cybernetic view, Frase (1968) concluded that the importance of nonverbal methods stemmed from their capacity to integrate appropriate reading responses at the time of exposure to the stimulus materials.

II
METHOD

SUBJECTS

Ss were 72 boys and girls in the eighth grade in the Sussex Elementary School system. These 72 Ss, and 7 others who were randomly discarded, made up the entire eighth-grade class of one of the local Sussex schools in the spring of 1968. Ages ranged from 13 years 2 months to 15 years 2 months. Three Ss were 15 years old, 16 Ss were 14, and the remainder were 13. The intelligence quotients, as measured by The Lorge-Thorndike Intelligence Tests (Level 4, Form A Verbal and Nonverbal) in the fall of 1966, ranged from 90 to 131. The median IQ of the 72 Ss was 111. The mean IQ was 111.64 with a standard deviation of 9.85. Ss had not been taught structural grammar prior to the experimental treatment.

Ss were contained in three English classes, two of which were taught by a young female teacher in her first year of service. The third class was taught by a male teacher of 11 years experience. Since all treatments were used within a classroom and since the programed format minimized the teacher role, it was felt that the difference between the two teachers would not be critical in influencing the experimental results.

EXPERIMENTAL DESIGN

The 72 Ss were stratified within each classroom on the basis of IQ so that three levels of an IQ factor could be used in analyses. Ss with an IQ higher than 116 were considered the high group; those with an IQ between 105 and 116 were the medium group; and those Ss with an IQ below 105 comprised the low group. This tripartition provided eight Ss in each classroom in each of the high, medium, and low groups.

The eight Ss in each IQ level in each classroom were assigned by a table of random numbers to one of four treatment conditions, with the restriction that there be equal numbers in each treatment group. Using this method of random assignment with restrictions, the classroom and teacher variables were equally represented in all treatments, and the twelve cells defined by the three IQ levels and four treatment conditions each contained six Ss. Table 1 presents the mean and standard deviation of IQ for each cell, row, and column in the experimental design. No statistically significant differences in IQ were present among the treatment groups.

EXPERIMENTAL TREATMENT

Three versions of five lessons in structural grammar were developed. The original programed lessons in structural grammar had been tested and are described elsewhere (Blount, Klausmeier, Johnson, Fredrick, & Ramsay, 1967; Blount, Johnson, & Fredrick, 1968). The five lessons taught the concepts of basic sentence, subject group, predicate group, noun, noun phrase, noun marker, noun test-sentence, verb phrase, forms of "be," completer, Pattern 1 sentence (NP + be + NP), adjective, adjective test-sentence, Pattern 2 sentence (NP + be + adj), adverb, Pattern 3 sentence (NP + be + adv), adverbs of place, adverbs of time, prepositional phrase, Pattern 4 sentence (NP + V), verb, optional adverb, adverbs of manner, noun phrase position, pronoun, and plural form. The three different versions of these five lessons were kept strictly equivalent in content, and only the mode in which the concepts were presented was varied. The modes were called verbal, symbolic, and figural.

In the verbal mode, concepts were presented as written statements without any attempt at abbreviation, coding, or symbolization of the concept. Thus, when a Pattern 1 sentence was being taught, the following statement might appear, "A Pattern 1 sentence is made up of a noun phrase, a be word, and a noun phrase." In the symbolic mode, concepts were presented

Table 1

The Experimental Design Showing the Mean IQ and Standard Deviation of IQ for Each Cell, Row, and Column

IQ Level	Experimental Treatment: Mode of Presentation Verbal	Symbolic	Figural	Control	All Ss
High 116-131	$\bar{X}$ = 124.67 sd = 3.78	$\bar{X}$ = 121.83 sd = 4.92	$\bar{X}$ = 124.50 sd = 4.81	$\bar{X}$ = 121.50 sd = 3.62	n = 24 $\bar{X}$ = 123.12 sd = 4.30
Medium 106-115	$\bar{X}$ = 110.67 sd = 1.75	$\bar{X}$ = 111.83 sd = 2.32	$\bar{X}$ = 111.83 sd = 2.64	$\bar{X}$ = 109.50 sd = 3.51	n = 24 $\bar{X}$ = 110.96 sd = 2.65
Low 90-105	$\bar{X}$ = 99.83 sd = 2.86	$\bar{X}$ = 101.33 sd = 2.25	$\bar{X}$ = 99.83 sd = 5.64	$\bar{X}$ = 102.33 sd = 3.61	n = 24 $\bar{X}$ = 100.83 sd = 3.71
All Ss	n = 18 $\bar{X}$ = 111.72 sd = 10.81	n = 18 $\bar{X}$ = 111.67 sd = 9.18	n = 18 $\bar{X}$ = 112.06 sd = 11.21	n = 18 $\bar{X}$ = 111.11 sd = 8.80	n = 72 $\bar{X}$ = 111.64 sd = 9.85

in symbolic codes and abbreviations wherever possible. The symbolic mode used the abbreviations S, N, NP, V, VP, NM, be, adj, adv, adv-t, adv-p, adv-m, prep, + (plus), and ———> (rewrites as), which the verbal mode did not use. Thus, Pattern 1 would be taught as "Pattern 1: NP + be + NP." In the figural mode, the abbreviations of the symbolic mode were placed into sentence-tree diagrams which gave a figural representation of many of the concepts. A total of 76 sentence trees were presented in the five lessons. Table 2 shows parallel frames from each version. Note that although the frames differ in appearance, the content is essentially the same in all three versions. In all cases, a sustained attempt was made to teach exactly the same content.

The fourth group was a control group that received five lessons in reading poetry. These lessons were in the same programed format as the structural grammar lessons, but no concepts of grammar were taught. The poetry lessons were an adaptation of part of an existing program (Reid, Ciardi, & Perrine, 1963).

TESTS

Two tests (Posttest and Retention Test) were developed to measure the learning that resulted from the experimental treatments. Every effort was made to have the test items favor none of the treatments. The items were constructed to get a measure of the ability of Ss to recognize and use the concepts that had been taught. The items could be characterized as performance items rather than as drawing upon memory of vocabulary. Each test contained 18 items, each item having several parts.

The stems of the items are shown in Table 3. The stems were exactly the same in both the Posttest and Retention Test. However, the sentences or words that followed the stems were changed in 16 of the 18 items. Only Item 16 and the True-False statements in Item 14 were the same from Posttest to Retention Test. The Retention Test was thus an alternate form of the Posttest, the tasks being exactly the same and only the particular problems differing.

The True-False statements of Item 14 were as follows:

T F A noun phrase sometimes has only one word.
T F A noun phrase has a verb in it.
T F Some noun phrases have noun markers.
T F An adverb will fit the noun test-sentence.
T F All completers contain a predicate group.
T F All completers are in the predicate group.
T F All predicate groups have completers.
T F All completers are noun phrases.
T F Prepositional phrases may act as adverbs.
T F All adverbs are prepositional phrases.
T F Adverbs tell who.
T F Adverbs of time are noun markers.
T F Adverbs of place and adverbs of time are all adverbs.
T F A prepositional phrase contains a noun phrase.

Table 2

Selected Frames from the Verbal, Symbolic, and Figural Versions of Five Lessons in Structural Grammar

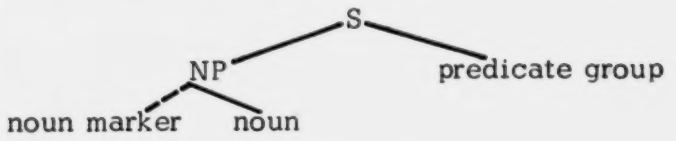
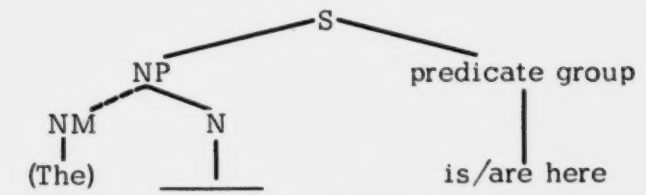
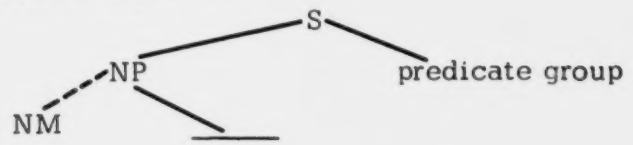
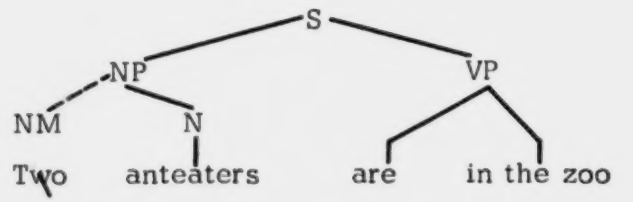
Verbal	Symbolic	Figural
35. The first part of the noun phrase, all but the last word, consists of words like <u>the</u>, <u>a</u>, <u>some</u>, <u>many</u>, <u>one of these</u>, and so on. These words are called NOUN MARKERS. < Many trees survived. > <u>Many</u> is called a _____ _____.	35. NP ——> (something) + noun The first part of the NP, represented by the word <u>something</u>, consists of words like <u>the</u>, <u>a</u>, <u>some</u>, <u>many</u>, <u>one of these</u>, and so on. These words are called NOUN MARKERS. Now complete the rewrite rule for an NP. NP ——> (_____ _____) + noun	35. The first part of the NP, represented by the dotted line, consists of words like <u>the</u>, <u>a</u>, <u>some</u>, <u>many</u>, <u>one of these</u>, and so on. These words are called NOUN MARKERS.  The first part of the NP is the _____ _____.
52. < (The) _____ is/are here. > The two main parts of all English sentences are the subject group and predicate group. The blank in this test-sentence indicates a noun position in the _____ group.	52. NM + N + pred. group < (The) _____ is/are here. > The two main parts of all English sentences are the subject group and predicate group. The blank in this test-sentence indicates a noun position in the _____ group.	52.  The two main parts of all English sentences are the subject group and predicate group. The blank in the noun test-sentence indicates N position in the _____ group.
66. A noun phrase is made up of a noun marker and a _____.	66. NP ——> NM + _____	66. What completes the NP in the following sentence tree? 
8. The first structure in the verb phrase of < Two anteaters are in the zoo. > is the word _____.	8. The first structure in the VP of < Two anteaters are in the zoo. > is the word _____.	8.  What is the first word in the VP of this sentence?

Table 2 continued

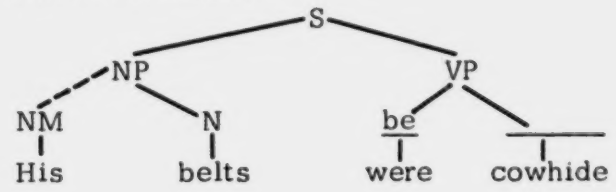
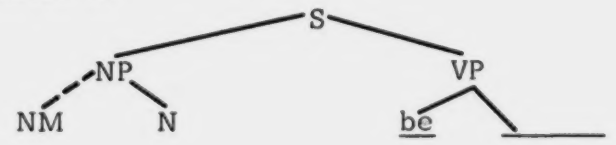
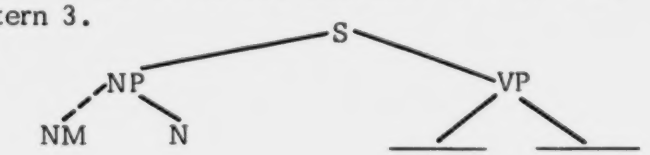
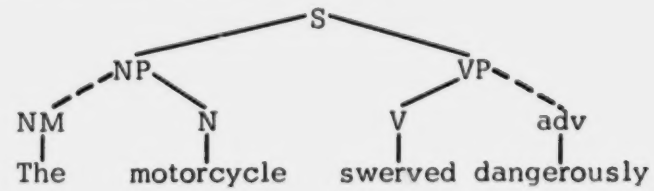
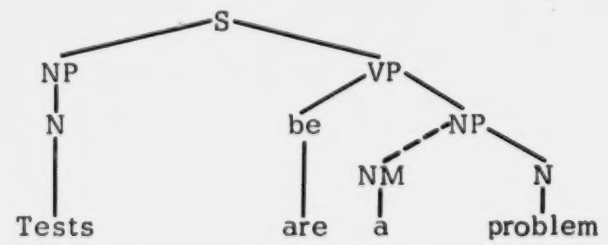
Verbal	Symbolic	Figural
26. Complete Pattern 1 for the following sentence. < His belts were cowhide. > Pattern 1: a noun phrase and a be word and a _____ _____.	26. Complete Pattern 1 for the following sentence. < His belts were cowhide. > Pattern 1: NP + be + _____.	26. Complete the sentence tree for the following Pattern 1 sentence. 
48. < These noodles are soggy. > is a Pattern 2 sentence. Pattern 2 is a noun phrase and a be word and an adjective. In Pattern 2, the completer is an _____.	48. < These noodles are soggy. > is a Pattern 2 sentence. We write Pattern 2 as: NP + be + adj In Pattern 2, the completer is an _____.	48. < These noodles are soggy. > is a Pattern 2 sentence. Fill in the missing completer for Pattern 2. 
8. Since an adverb acts as the completer for Pattern 3, we will write the pattern as: a noun phrase, a _____ word, an _____	8. Since an adv acts as the completer for Pattern 3, we will write the pattern as: NP + _____ + _____	8. Fill in the VP in this sentence tree for Pattern 3. 
26. Although Pattern 4 does not have a completer, we often use an adverb after the verb. < The motorcycle swerved dangerously. > Here dangerously is an _____ after the verb.	26. Although Pattern 4 does not have a completer, we often use an adv after the V. < The motorcycle swerved dangerously. > Here dangerously is an _____ after the V.	26. Although Pattern 4 does not have a completer, we often find an adv after the V.  Here dangerously is an _____ after the V.
17. < Tests are a problem. > What noun marker do you find in the underlined noun phrase?	17. < Tests are a problem. > What NM do you find in the underlined NP?	17.  What NM do you find in the NP completer of this Pattern 1 sentence?

Table 3

Item Stems Used in the Posttest and Retention Test

Item No.	Stem	Problems
1.	Mark the two main parts of each of the following sentences by drawing a line between the subject group and predicate group.	10 sentences
2.	Put an S before the groups of words you think have a complete subject group and a complete predicate group.	10 groups of words
3.	Put an X before the sentences which have the pattern: noun phrase, a form of be, and a noun phrase (NP + be + NP).	10 sentences
4.	Put an X before the words which will complete the noun test-sentence satisfactorily.	10 words
5.	Put an X before the words which will complete the adjective test-sentence satisfactorily.	10 words
6.	Put an X before the words which have a plural form that is spelled differently from the singular.	10 words
7.	Circle the noun markers in these sentences. Some sentences may have none; some more than one.	10 sentences
8.	Put an X before the sentences which are like the pattern: noun phrase, a form of be, an adjective (NP + be + adj).	10 sentences
9.	Put an X before the sentences which are like the pattern: noun phrase, a form of be, an adverb (NP + be + adv).	10 sentences
10.	Put an X before the sentences which are like the pattern: noun phrase, and a verb (NP + V). There may be an optional adverb.	10 sentences
11.	Underline the adverbs in these sentences. Some sentences may not have an adverb.	10 sentences
12.	Underline the noun phrase(s) in these sentences. Some sentences will have more than one noun phrase.	10 sentences
13.	Underline the noun(s) in each sentence.	10 sentences
14.	Circle the T before all the statements that are true. Circle the F before all those that are false.	21 statements (9 true)
15.	Circle all the forms of be that you find. Some sentences may not have a form of be.	10 sentences
16.	Put an X before the structures that may act as completers.	10 concepts
17.	Out of each group of sentences find the one (1) sentence whose pattern is different from the other two. Put an X on the line in front of it.	8 groups of 3 sentences
18.	Show the structure of these sentences (using either labels, rewrite rules, or sentence trees).	3 sentences
T F	A noun phrase contains a noun.	
T F	A prepositional phrase contains a noun.	
T F	A noun phrase usually contains a prepositional phrase.	
T F	A noun phrase always contains a noun marker.	
T F	All sentences are basic sentences.	
T F	Some basic sentences have more than a subject group and a predicate group.	
T F	A noun marker comes before a noun.	

These statements were unlike the other questions because they required a knowledge of the relationship among concepts. In effect, the True-False items required S to reason in terms of the concepts he had learned, while the other questions dealt mainly with the identification of specific instances of concepts.

PROCEDURE

After preliminary contacts with the principal and English teachers at a Sussex Elementary School, the experiment was scheduled to begin Thursday, February 22, 1968. Prior to this time the entire eighth grade at this school

had received no instruction in structural grammar and had not worked with programed lessons.

The lessons were prepared in three versions by the present authors. Copies of all three versions and the poetry lessons for the control group were sent to the two teachers two weeks before the experiment. The teachers were to acquaint themselves with the lessons so that they could handle questions that might arise. A week before the experiment, a meeting was held with the teachers and the principal. At this meeting detailed instructions were given on experimental procedures. The following procedures were developed:

1. The students were not told they were participating in an experiment. Teachers explained to them that the week's work had been individualized for each person's particular needs, that each person was learning the content that was appropriate to his level and needs.

2. Students were randomly assigned to treatments, and each classroom had all four treatments (three versions of structural grammar and a control group studying poetry interpretation) in use simultaneously. Work on the lessons was an individual activity, but other classroom activities could proceed as usual before or after the actual study of the lessons. A literature assignment was given each student, and this assignment was pursued each day after the lesson in structural grammar was completed.

3. When questions were asked, the teachers handled these individually by referring the student to the frames related to the question.

4. No other instruction in grammar was given during the course of the experiment.

5. If a student was absent, he was to do two lessons on the day of his return.

6. The five lessons were given one per day on February 22, 23, 26, 27, and 28. The Post-test was given on Friday, March 1 following a one day rest on Thursday, February 29. The Retention Test was given Friday, March 15, after a period of two weeks in which no grammar was taught

The oral discussion of procedures was followed by written instructions to the teachers. These written instructions explained in more detail the points discussed at the meeting and served as a reference sheet for the teachers. The written instructions were as follows:

Note: An important consideration in making decisions about procedures not covered here is that the decision should be the same for each classroom and should not affect one treatment group more than another.

Procedures

First day of experiment, February 22:

Explain to the students that the week's work has been individualized, that each person is learning in a format most appropriate to him and is learning what he most needs to know. Do not tell him he is a subject in an experiment.

Inform the student that the first day he is to do Lesson 1. Instruct him in the use of the programed materials, i.e., how to use the response sheet to cover the answers on the program, how to respond to each frame and then check his written response against the given response. If he is correct he should continue, if wrong he should put a line through the wrong response and write the correct one. He should make comments about frames if he has any. He should work at a comfortable rate and with an attempt to understand what is being taught by each frame. He can review or make notes on the program, but all work should be done during the class period. After he finishes the lesson to his satisfaction, he should have some reading to occupy him until the end of the hour.

When answering questions, try to handle these with the individual. Refer him back to the relevant sections or discuss the problem with him in the mode he is using. You may help students with the reading or pronouncing of words, and with mechanical problems such as how to use the response sheet as a shield, but let the program do the teaching.

After the period, all materials should be collected by the teacher. Check the response sheets to see that students are working conscientiously on the programs. Please jot down any occurrences that you think might affect the experimental results.

Successive lessons, February 23-28:

As the experiment proceeds, be sure that students get their proper lesson folder each day. Try to have absentees catch up as soon as possible. The students should not work ahead, but they can go back and review previous lessons. Encourage them to work with understanding and to comment on parts of the lessons as they desire. Try to continue the atmosphere of the lessons being an important teaching device which is teaching various individualized aspects

of regular coursework. Announce that they will be tested Friday on the material they are studying.

Posttest, March 1:

This test will take up nearly all of the period. Try to have students work at a rate which will allow them to do all the questions.

When giving the test say to the students:

Write your name and the date at the top of the first page. (Give the date.)

This is an inventory of what you know about grammar. Each of the questions has several parts, and you should try to answer each question to the best of your ability.

If you don't know an answer, you can guess.

To make sure everyone finishes, I will tell you at various times how far you should be. You can work faster, but try not to fall behind.

If you finish before the bell, check over your work to be sure you answered all the questions.

You can start now on Page 1.

Retention Test, March 15:

This test should be a surprise to the student. It is an alternate form of the Posttest and should be given in exactly the same manner.

III
RESULTS

STUDY TIME

Ss had been instructed to record their starting and stopping time each day. The tabulations of the time in minutes spent on the lessons are summarized in Table 4. The first lesson in grammar required an average of 28.1 minutes, while the next four lessons took less time, averaging 20.7 minutes. The high, medium, and low ability Ss averaged 21.5, 22.2, and 22.9 minutes, respectively, for each of the five grammar lessons. The verbal, symbolic, and figural groups averaged 22.4, 21.6, and 22.6 minutes, respectively. Essentially, a S spent slightly less than two hours in the study of structural grammar prior to the Posttest. The higher ability Ss tended to be somewhat faster than the medium ability Ss who in turn were faster than the low ability Ss, but the three versions of the structural grammar program did not differ greatly in study time required. The Pearson product-moment correlation between time and Posttest errors was not significant ($r = +.07$) indicating that time was not the critical factor in determining the amount of learning.

ANALYSES

The mean numbers of errors on each question are presented in Table 5 for both the Posttest and Retention Test. The within-cell error correlation between each pair of items is also shown in Table 5. Tests of significance between two means for correlated samples showed that none of the questions differed significantly from Posttest to Retention Test. As alternate forms, the tests showed a reliability coefficient of .93, even though a two-week interval elapsed between tests.

In Table 6 the Posttest means for the treatment groups and ability groups are presented. In Table 7 the Retention Test means are presented for these same groups. Each item in the 18 item Posttest and Retention Test was analyzed by a two-way fixed-effects model analysis of variance. The factors tested by F ratios were ability (High vs. Medium vs. Low), treatment (Control vs. Experimental; Verbal vs. Symbolic and Figural; Symbolic vs. Figural), and interactions (ability by treatment). A summary of the significance level of the F ratios for these factors is presented in Table 8 for

Table 4

Time in Minutes Spent on the Five Programed Lessons
in Structural Grammar and the Poetry Lessons of the Control Group

Groups N = 18	Lesson Number (No. of Frames in Parentheses) 1(70)	2(62)	3(65)	4(60)	5(70)	Total Time
Low Ability	507	429	394	353	381	2064
Medium Ability	532	403	390	328	344	1997
High Ability	479	365	345	361	383	1933
Verbal	501	409	389	332	382	2013
Symbolic	504	390	342	353	357	1946
Figural	513	398	398	357	369	2035
Control	557	431	418	543	353	2302

Table 5

Errors on the Posttest and Retention Test

Item	Posttest Mean	Posttest sd	Retention Test Mean	Retention Test sd	Within Cell Correlation
1. Subject-Predicate	1.36	2.1	1.65	2.7	.40
2. Complete Sentences	2.06	1.6	1.68	1.7	.33
3. Pat. 1 NP + be + NP	4.62	1.9	4.15	2.0	.47
4. Noun Test-sentence	2.32	1.9	2.89	2.1	.47
5. Adj Test-sentence	2.90	2.0	2.57	2.1	.60
6. Plural form	3.53	2.6	3.29	3.2	.50
7. Noun Markers	12.18	5.8	11.74	5.9	.77
8. Pat. 2 NP + be + adj	2.92	1.9	2.83	2.0	.36
9. Pat. 3 NP + be + adv	4.89	1.8	5.15	1.8	.13
10. Pat. 4 NP + V	4.32	1.8	4.19	2.0	.32
11. Adverbs	8.92	2.1	8.82	2.8	.71
12. Noun Phrases	8.97	4.6	7.83	5.0	.61
13. Nouns	3.38	3.6	4.10	4.5	.70
14. True-False	6.99	2.9	7.17	3.0	.33
15. Forms of be	4.36	3.0	3.96	3.1	.61
16. Completers	3.83	1.8	3.78	1.9	.13
17. Pattern Comparison	4.22	1.8	3.88	1.5	.39
18. Sentence Structure	8.35	4.8	8.56	5.0	.72
Sum of 1, 2, 15, 16, 18 (Sentence Parts)	19.94	9.5	19.62	10.1	.72
Sum of 3, 8, 9, 10, 17 (Patterns)	20.97	5.4	20.22	5.9	.56
Sum of 4, 6, 7, 12, 13 (Nouns)	30.24	13.8	29.83	15.9	.80
Sum of 5, 11 (Modifiers)	11.81	3.5	11.39	4.2	.78
Sum of 1–18 (Total)	89.94	30.2	88.24	33.2	.87

each of the 18 items for both the Posttest and Retention Test. Also presented in Tables 5–8 are the data for the total score and for groups of questions as described in Table 5. Table 9 shows the complete analyses of variance for the Posttest and Retention Test total scores. Table 10 presents the Pearson product-moment correlation coefficient between each item and total score.

The Ability Factor

Three ability groups were defined on the basis of the Lorge-Thorndike IQ. Ss with IQ scores above 116 were High; 105-116 were Medium; and below 105 were Low. On the Posttest, the differences among High, Medium, and Low were highly significant ($p < .001$). The High group averaged 71 errors while the Medium and Low groups averaged 91 and 108 errors, respectively. These errors were out of a possible 215 points, with the grand mean being 90 errors and the standard deviation 30. These differences were still highly significant when groups of questions were considered. The High Ss made fewer errors on questions dealing with sentence parts, sentence patterns, nouns, and modifiers than did the Medium Ss who in turn made fewer errors than the low Ss. Thirteen of the 18 Posttest questions showed differences that were significant at or beyond the .10 level. (See Table 8 for exact probabilities.) The differences between High, Medium, and Low were especially noticeable on answering True-False questions, finding noun markers, finding forms of be, marking completers, marking Pattern 4, and completing the adjective test-sentence (Questions 14, 7, 15, 16, 10, and 5, respectively). The High Ss performed well in comparison to the Medium and Low Ss in finding Pattern 1, labeling sentence parts, and finding noun phrases (Questions 3, 18, and 12, respectively). Differences were also significant on Questions 1, 2, 11, and 17, which dealt with dividing a sentence into two parts, marking complete sentences, finding adverbs, and comparing sentence patterns.

Table 6

Errors Made by High, Medium, and Low Ability Ss and
by Ss in Verbal, Symbolic, Figural, and Control Groups on the Posttest

Item	High		Medium		Low		Verbal		Symbolic		Figural		Control	
	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd
1.	.71	1.9	1.29	1.5	2.08	2.5	1.44	2.1	1.50	1.8	1.11	1.9	1.39	2.6
2.	1.62	1.6	1.88	1.3	2.67	1.7	2.22	1.6	1.67	1.3	1.78	1.5	2.56	1.9
3.	3.83	2.0	5.12	1.9	4.92	1.6	5.11	2.3	4.44	1.6	4.00	2.2	4.94	1.5
4.	1.96	1.7	2.25	1.9	2.75	2.0	1.78	2.2	2.17	1.8	2.50	1.9	2.83	1.8
5.	1.92	1.9	2.88	1.7	3.92	2.0	2.89	1.9	2.78	2.1	2.61	2.0	3.33	2.1
6.	3.00	2.8	3.33	2.7	4.25	2.3	4.11	2.5	2.61	2.7	2.83	2.2	4.56	2.8
7.	8.88	6.2	12.58	5.5	15.08	3.9	11.94	6.7	11.00	4.9	11.72	5.4	14.06	6.0
8.	2.50	2.1	2.71	1.5	3.54	2.0	2.39	2.0	2.22	1.7	3.17	1.6	3.89	2.1
9.	4.79	1.8	5.12	1.8	4.75	1.8	4.50	2.0	4.94	1.5	4.72	1.8	5.39	1.9
10.	3.58	1.7	4.17	1.8	5.21	1.4	4.17	2.3	4.11	1.3	4.17	1.9	4.83	1.3
11.	8.17	1.8	8.96	2.3	9.62	1.8	9.39	2.0	8.72	1.8	8.00	2.5	9.56	1.5
12.	7.12	4.3	9.42	4.5	10.38	4.4	9.28	4.7	7.06	3.7	8.06	4.9	11.50	3.9
13.	2.46	3.4	3.12	3.4	4.54	4.0	3.56	3.9	2.89	3.1	3.33	4.0	3.72	3.8
14.	5.17	2.6	6.96	2.4	8.83	2.4	7.06	3.2	6.11	2.1	6.22	3.2	8.56	2.3
15.	3.04	2.8	4.42	3.1	5.62	2.7	4.67	3.1	3.33	2.4	3.11	2.7	6.33	2.9
16.	3.08	1.7	3.62	1.6	4.79	1.7	3.89	1.6	3.67	2.1	3.17	1.7	4.61	1.5
17.	3.62	2.0	4.25	1.5	4.79	1.7	4.44	2.2	3.77	1.5	3.61	1.8	5.06	1.1
18.	5.75	4.3	9.46	5.1	9.83	3.9	9.06	4.3	6.44	2.4	7.00	5.8	10.89	5.0
Parts	14.17	9.8	20.67	8.1	25.00	7.4	21.28	9.1	16.61	5.6	16.11	11.5	25.78	8.0
Patterns	18.33	6.7	21.38	4.5	23.21	3.7	20.61	6.9	19.50	3.4	19.67	5.4	24.11	4.1
Nouns	23.00	14.8	30.71	12.8	37.00	10.4	30.68	15.3	25.33	10.8	28.44	15.5	36.50	11.9
Modifiers	10.08	3.0	11.83	3.5	13.50	3.1	12.22	3.3	11.50	3.2	10.61	4.1	12.89	3.0
Total	70.75	32.5	91.54	26.4	107.54	18.6	91.83	33.1	79.06	21.5	81.06	35.3	107.83	21.1

Table 7

Errors Made by High, Medium, and Low Ability Ss and by Ss in Verbal, Symbolic, Figural, and Control Groups on the Retention Test

Item	High		Medium		Low		Verbal		Symbolic		Figural		Control	
	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd
1.	.96	2.5	1.79	2.6	2.21	2.9	1.89	3.1	1.61	1.9	1.50	2.5	1.61	3.2
2.	1.00	1.4	1.92	1.7	2.12	1.8	1.72	2.1	1.28	1.2	1.56	1.6	2.17	1.9
3.	3.21	2.1	4.62	2.0	4.62	1.6	4.72	1.9	3.72	1.9	4.22	2.2	3.94	2.0
4.	1.79	1.5	3.04	2.2	3.83	2.1	3.11	2.2	2.56	1.8	2.28	1.9	3.61	2.3
5.	1.88	2.0	2.67	2.2	3.17	2.0	2.89	2.4	2.22	2.0	2.11	1.8	3.06	2.2
6.	1.96	2.9	3.38	3.3	4.54	3.0	3.50	3.1	1.72	2.3	3.11	3.6	4.83	3.3
7.	9.21	6.0	11.04	5.6	14.96	4.6	11.56	6.6	11.22	5.3	10.78	5.7	13.39	6.1
8.	1.79	1.6	2.88	1.7	3.83	2.1	2.50	2.0	2.11	1.8	3.06	2.1	3.67	1.8
9.	4.38	1.8	5.21	1.7	5.88	1.5	5.28	1.8	5.11	1.7	5.11	1.9	5.11	1.8
10.	3.42	2.3	4.21	1.4	4.96	1.8	3.72	1.9	4.11	1.7	4.50	2.3	4.44	2.0
11.	7.67	3.0	8.71	2.4	10.08	2.5	9.22	2.6	8.67	2.8	7.78	3.8	9.61	1.3
12.	6.04	5.0	7.00	4.4	10.46	4.8	7.28	4.6	6.44	4.0	7.44	4.8	10.17	6.1
13.	2.12	3.3	4.42	5.0	5.75	4.6	4.39	4.5	3.33	3.1	3.06	4.7	5.61	5.6
14.	4.71	2.5	7.50	2.4	9.29	2.1	7.72	3.3	6.94	3.0	6.11	3.4	7.89	2.0
15.	2.38	2.5	4.50	3.3	5.00	3.0	4.50	3.9	3.00	2.2	3.11	2.7	5.22	3.1
16.	2.88	1.8	4.00	2.1	4.46	1.6	3.56	1.8	3.67	1.4	3.17	2.2	4.72	2.1
17.	3.54	1.6	3.88	1.6	4.21	1.4	4.28	1.6	3.72	1.3	3.33	1.9	4.17	1.3
18.	6.08	4.9	9.42	5.1	10.17	4.1	8.67	4.4	7.83	3.7	7.22	5.9	10.50	5.3
Parts	13.29	9.7	21.62	9.5	23.96	8.1	20.33	10.2	17.39	5.8	16.56	12.1	24.22	10.2
Patterns	16.38	6.4	20.79	5.2	23.50	3.3	20.50	6.7	18.78	5.3	20.28	7.2	21.33	4.0
Nouns	21.08	15.0	28.88	14.1	39.54	13.2	29.83	16.3	25.28	10.2	26.61	17.3	37.61	16.9
Modifiers	9.54	4.2	11.38	3.8	13.25	3.9	12.11	4.3	10.89	4.1	9.89	5.1	12.67	2.6
Total	65.00	32.5	90.17	26.4	109.54	18.6	90.50	33.1	79.28	21.5	79.44	35.3	103.72	21.1

Table 8

Significance Level of F ratios for the Factors Ability (High vs. Medium vs. Low—HvMvL) and Treatment (Control vs. Experimental—CvE; Verbal vs. Symbolic and Figural—VvS,F; Symbolic vs. Figural—SvF), and for the Interactions (Ability x Treatment—Int)

	Posttest					Retention Test				
Item	HvMvL	CvE	VvS,F	SvF	Int	HvMvL	CvE	VvS,F	SvF	Int
1. Subject-Predicate	.091	—	—	—	—	—	—	—	—	—
2. Complete Sentences	.047	—	—	—	—	.066	—	—	—	—
3. Pat. 1 NP + be + NP	.024	—	.076	—	.012	.016	—	—	—	—
4. Noun Test-sentence	—	—	—	—	.006	.001	.062	—	—	—
5. Adj Test-sentence	.003	—	—	—	—	—	—	—	—	—
6. Plural Form	—	.047	.058	—	—	.011	.011	—	—	—
7. Noun Markers	.001	.077	—	—	—	.001	—	—	—	.058
8. Pat. 2 NP + be + adj	—	.010	—	—	—	.001	.022	—	—	—
9. Pat. 3 NP + be + adv	—	—	—	—	—	.015	—	—	—	—
10. Pat. 4 NP + V	.005	—	—	—	—	.019	—	—	—	—
11. Adverbs	.031	.098	.061	—	—	.010	—	—	—	—
12. Noun Phrases	.013	.002	—	—	.008	.002	.009	—	—	.014
13. Nouns	—	—	—	—	.015	.013	.080	—	—	—
14. True-False	.001	.001	—	—	.067	.001	.093	.050	—	.006
15. Forms of be	.004	.001	.058	—	—	.006	.037	.090	—	—
16. Completers	.001	.019	—	—	—	.010	.012	—	—	—
17. Pattern Comparison	.054	.015	—	—	—	—	—	.096	—	—
18. Sentence Structure	.001	.003	.052	—	—	.005	.035	—	—	.057
Sentence Parts	.001	.001	.024	—	.091	.001	.010	—	—	—
Patterns	.003	.002	—	—	—	.001	—	—	—	.094
Nouns	.001	.006	—	—	.001	.001	.003	—	—	.006
Modifiers	.002	.096	—	—	—	.009	—	—	—	—
Total	.001	.001	.067	—	.005	.001	.004	—	—	.032
Total, using Ability as a Covariate		.001	.068	—	.011		.005	—	—	.056

Note—A dash indicates that the significance level of the F ratio was not less than .10.

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Table 9

Analysis of Variance of the Posttest and Retention Test Total Scores

Source	df	Posttest		Retention Test	
		Mean Square	F ratio	Mean Square	F ratio
Ability	2	8167.68	17.07	11970.85	19.08
Treatment	3				
Control vs Experimental	(1)	7680.30	16.05	5755.67	9.17
Verbal vs Symbolic & Figural	(1)	1664.59	3.48	1488.90	2.37
Symbolic vs Figural	(1)	36.00	.08	.25	.00
Interaction	6	1696.59	3.55	1559.88	2.49
Error	60	477.91		624.01	

$F_{.95(2,60)} = 3.15$ $F_{.95(1,60)} = 4.00$ $F_{.95(6,60)} = 2.25$

$F_{.99(2,60)} = 4.98$ $F_{.99(1,60)} = 7.08$ $F_{.99(6,60)} = 3.12$

Table 10

Correlation of Item Score with Total Score and Intelligence

Item	Posttest Items Correlated with			Retention Test Items Correlated with		
	Posttest Total	Retention Test Total	IQ*	Retention Test Total	Posttest Total	IQ*
1.	.50	.47	.30	.57	.48	.24
2.	.47	.43	.31	.64	.57	.34
3.	.50	.46	.29	.45	.39	.31
4.	.58	.56	.20	.64	.57	.44
5.	.67	.66	.42	.61	.57	.26
6.	.50	.41	.22	.61	.62	.40
7.	.82	.74	.47	.74	.76	.42
8.	.47	.35	.25	.60	.56	.44
9.	.22	.12	.01	.42	.34	.30
10.	.46	.47	.36	.47	.43	.37
11.	.65	.68	.32	.60	.60	.34
12.	.79	.74	.38	.74	.67	.40
13.	.54	.58	.26	.72	.58	.35
14.	.71	.66	.59	.74	.70	.67
15.	.70	.62	.36	.67	.68	.39
16.	.60	.53	.44	.51	.49	.35
17.	.69	.62	.34	.51	.42	.23
18.	.71	.68	.37	.62	.58	.36

* The correlations involving IQ are all negative.

The Retention Test, which was given two weeks after the Posttest, showed significant differences among High, Medium, and Low groups on total score, on groups of questions (parts, patterns, nouns, and modifiers), and on 15 of the 18 individual questions. The average total errors made by the High, Medium, and Low groups were 65, 90, and 110, respectively, where 218 points were possible, with the grand mean being 88 and the standard deviation 33. Only differences on Questions 1, 5, and 17 were not significant, though the differences between High, Medium, and Low tended in the proper direction.

The Pearson correlation between IQ and total errors was -.55 on the Posttest and -.60 on the

Retention Test. These correlations represented a significant degree of relationship between intelligence and performance on the present task. Individual questions also correlated to some extent with IQ as shown in Table 10. Questions showing the highest correlations with IQ were True-False, finding noun markers, and marking completers.

Control vs. Experimental

The Control group averaged 108 errors on the Posttest and 104 errors on the Retention Test. The Experimental groups averaged 84 and 83 errors, respectively. The Experimental groups made significantly fewer errors on both the Posttest and Retention Test ($p < .01$). Thus, the learning gains made by the Experimental groups on the Posttest persisted during the two-weeks interval and the Retention Test.

The most significant differences between Control and Experimental groups were in the Posttest questions dealing with sentence parts, patterns, and nouns (Table 8). The difference in knowledge of patterns was not significant after two weeks, but knowledge of sentence parts and nouns still showed significant differences on the Retention Test. Specifically, Questions 6, 7, 8, 11, 12, 14, 15, 16, 17, and 18 of the Posttest showed significant differences in favor of the Experimental groups. Of the 10 questions significant on the Posttest, 7 showed significant differences after two weeks. Six of these dealt with plural form, Pattern 2 (NP + be + adj), noun phrases, forms of be, completers, and labeling of sentence parts. The other question was the set of 21 True-False statements.

When ability was used as a covariate, the differences between the total errors made by Experimental and Control groups were still significant ($p < .01$) and in favor of the Experimental groups.

Verbal vs. Symbolic and Figural

The only difference between the treatment conditions of the Verbal group and of the Symbolic and Figural groups was that in the last two, concepts were presented in modes that went beyond verbal statement. In the Symbolic mode, concepts were presented as rewrite rules (i.e., NP ———> NM + N). The Figural mode contained a number of sentence trees which gave a pictorial representation of the concepts of grammar.

The Verbal group averaged 92 errors while the Symbolic and Figural groups averaged 80 errors on the Posttest. This difference was significant ($p < .07$) and seemed to result mainly from the ability of the Symbolic and Figural groups to perform better on questions dealing with sentence parts ($p < .03$), especially Questions 15 and 18. Three other Posttest questions (3, 6, 11) showed the Symbolic and Figural groups significantly superior to the Verbal. Only Questions 1, 4, 8, 9, and 10 did not show the Symbolic and Figural groups scoring better than the Verbal group.

On the Retention Test the Verbal group averaged 11 more errors on total score than did the Symbolic and Figural groups, but this difference just missed statistical significance at the .10 level. Fourteen of the 18 individual questions showed differences in the direction of poorer performance for the Verbal group. The set of True-False statements, and the questions on forms of be and comparing patterns showed significant differences ($p < .10$) on the Retention Test, and these differences were all in favor of the Symbolic and Figural groups.

Symbolic vs. Figural

No significant differences were present in the comparison of the Symbolic and Figural groups. On the Posttest, the Symbolic and Figural groups averaged 79 and 81 errors, respectively, and on the Retention Test both averaged 79 errors. On the Posttest, 10 questions favored the Symbolic group and 8 favored the Figural group, while on the Retention Test the split was still more even. It appears that only random fluctuations differentiated the Symbolic and Figural groups and that either or both the rewrite rules and sentence trees were welcome assets in the teaching of structural grammar.

Interaction of Treatment and Ability

Table 8 shows that the interaction of ability and treatment was statistically significant ($p < .10$) for several individual questions, groups of questions, and total score on both the Posttest and Retention Test. The interactions appeared to have the same characteristics in each case. Fig. 1 presents the graph of the interaction for total Posttest score. From this graph it is apparent that high ability Ss benefited from any of the three experimental conditions. Medium Ss benefited only when the Figural and Symbolic treatments were used. Low Ss benefited only from the Symbolic and Verbal treatments. Close study of Fig. 1 will reveal that only the Symbolic treatment was uniformly successful in teaching high, medium, and low ability Ss. The Figural treatment was not appropriate for low ability Ss although High

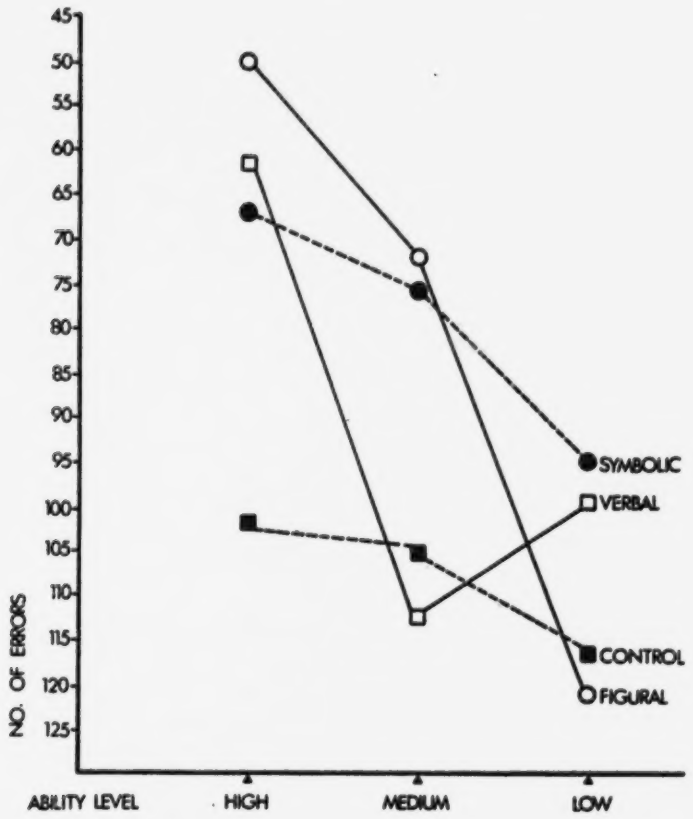

Fig. 1. The Treatment by Ability Interaction on the Posttest

and Medium Ss worked well with this treatment. Perhaps the representation involved in the figural sentence trees was too advanced for low ability Ss. The Verbal treatment was acceptable for high ability Ss, but failed for the Medium group. A preliminary conclusion from these results is that learning of grammar concepts can be enhanced through the use of symbols and diagrams, provided that the symbols and diagrams are not overly complex to the low ability student.

Forgetting Over the Two-Week Interval

If the performance of the Control group is used as a base level for both the Posttest and Retention Test, then one can compare the performance of the Experimental groups from Posttest to Retention Test. Such a comparison revealed that the loss in knowledge was approximately 13.4% (i.e., 3.2 more errors made by the Experimental groups on the Retention Test than on the Posttest). The Verbal, Symbolic, and Figural groups showed losses in knowledge of 16, 14, and 9%, respectively, over the two weeks. Thus, forgetting was rather slight, and the differences among experimental groups in amount of forgetting were also minimal. All three versions of the programed lessons produced stable, usable knowledge, and no differences among the versions were apparent on the basis of long-term retention. However, one must consider the fact that the Symbolic and Figural treatments produced more initial learning than the Verbal treatment.

DISCUSSION

The results were rather clear and seem to have important implications for instructional methods. Aside from the fact that all three versions of lessons in structural grammar produced substantial and lasting increases in the ability to recognize sentence patterns, plural forms, forms of be, and noun phrases, and to determine the structure of sentences and the relationships between concepts, the facilitative effects of a symbolic notation and figural representation of concepts were also apparent. The symbolic notation and sentence trees produced some immediate improvement on several performance measures, such as recognition of sentence structures, and caused a more permanent increase in the ability to view the relationships among concepts correctly. The experiment demonstrated that programed instruction in a verbal area could be enhanced by using more than verbal means. A symbol system, which presented information more compactly than the corresponding verbal statement, produced increases in learning that were detected initially and after two weeks. Likewise, a figural representation using sentence trees produced more learning than verbal presentation of the same concepts. These modes may have been successful because they brought additional contents from the structure of intellect into play or because they added economy and power to the learning. Increased motivation and interest resulting from the use of symbols and figures may also have accounted for the significant differences. The experiment offered no justification to the idea that verbal information should be taught exclusively verbally.

An important finding was the interaction between treatment and ability. Presenting concepts only verbally was not optimal for either high, medium, or low ability Ss. In fact, only high ability Ss could profit from it to any great extent. Employing a symbolic notation, in the present case rewrite rules, seemed a worthwhile aid for all ability levels. A somewhat more complex aid, figural sentence trees, helped the medium and high ability groups but was apparently not very useful to the low ability group. It may be that the low ability Ss were not capable of learning from the sentence trees without additional instruction in the applicability of the diagram per se.

The presence of the significant interaction between mode of representation and ability

suggests that Bruner's concern with matching the mode of representation to the abilities of the learner is entirely warranted. Thus, one must not only be aware of the notation, displays, and models that explicate a subject-matter field advantageously, but also of the experience and intelligence of the learner for whom the notation, display, or model must be a vehicle toward understanding rather than a stumbling block.

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